SOUTHEASTERN
REGIONAL
BIOMASS ENERGY
PROGRAM

SERBEP
Update

OCTOBER 1995

A Publication for the General Biomass Community

The Southeastern Regional Biomass Energy Program is one of five regional biomass energy programs. It is administered for the U.S. Department of Energy Office of National Programs by the Tennessee Valley Authority's Environmental Research Center in Muscle Shoals, Alabama. The 13-state region includes Florida, Kentucky, Mississippi, Georgia, North Carolina, South Carolina, Virginia, West Virginia Missoun, Tennessee, Louisiana, Arkansas, and Alabama.

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HIGHLIGHTS OF THE SECOND BIOMASS CONFERENCE OF THE AMERICAS

The Second Biomass Conference of the Americas was held August 21-24, 1995, in Portland, Oregon. We have invited Don Klass, program chairman, to provide an overview of the conference. Dr. Klass, formerly with the Institute of Gas Technology (IGT), is President of the Biomass Energy Research Association (BERA) and Director, Research, of Entech International, Inc., a consulting firm located in Barrington, Illinois. Dr. Klass can be reached by phone or fax at 708-382-5595.

As the First Biomass Conference of the Americas held in Burlington, Vermont, in 1993, the Second Biomass Conference of the Americas was designed to provide a national and international forum to support the development of a viable biomass industry. The sponsors of the conference were the US Agency for International Development, the US Departments of Agriculture and Energy, the US Environmental Protection Agency, Natural Resources Canada, and the National Renewable Energy Laboratory, under whose auspices the conference was presented. The cosponsors were Cargill, Inc., Clean Fuels Development Coalition, Delta-T Corporation, Northwest Power Planning Council, Tenn/Ark Development Joint Venture, and Winrock International. Our intent is to present this conference biennially in odd years in coordination with the European Bioenergy Conference which is presented in even years. The Third Biomass Conference of the Americas is scheduled for presentation in Canada in 1997.

About 450 registrants attended the Second Biomass Conference of the Americas from North and South America, Europe, and other parts of the world. Papers on research activities and technologies under development that address industry problems were included in the program, but the main emphasis was on scale-up and demonstration projects, technology transfer to end users, and commercial applications of virgin and waste biomass. The conference was divided into these subject areas:

- Resource Base
- Power Production
- Transportation Fuels
- Chemicals and Products
- Economic, Financial, and Policy Issues

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- Sustainability and Environmental Issues
- European Biomass Energy Developments
- Latin American Biomass Energy Developments

It was evident from the oral and poster papers presented at the conference and from conversations with many of the attendees that projects for the production of energy and biofuels from virgin and waste biomass are receiving the undivided attention of many entrepreneurs, partnerships, and companies. Many new waste biomass energy projects have either been scaled-up or commercialized or are in the process of entering this phase since the First Biomass Conference of the Americas was presented. This is occurring despite the fact that government budgets are tight, financing is difficult to obtain, oil and natural gas prices are still low, and the future of some of the tax incentives available for biomass projects is questionable. The driving forces today for these projects are mainly waste disposal and environmental issues. The momentum to pursue biomass energy commercialization has definitely not subsided. If anything, it is growing at a faster pace now than it was a few years ago. Biomass project entrepreneurs certainly find themselves in an exciting time because there are many opportunities ready for commercial development.

In the remainder of this article, I will present a few comments on what I consider to be the highlights of the Second Biomass Conference of the Americas and also offer a few editorial comments where I believe they are appropriate. (For similar treatment of the First Biomass Conference of the Americas, see *SERBEP Update*, October 1993.) I again caution the reader to keep in mind that because of space constraints, it is necessary to limit these comments. References are not listed. The 1,741-page proceedings contain most of the oral and poster papers, so I urge the reader to examine the book for details. The book is available for purchase from Milly Lemmons, National Renewable Energy Laboratory, 1617 Cole Blvd., Golden, CO 80401, phone (303) 275-3098, fax (303) 275-3097. Proceedings are $50 each. Payment may be made in any form except credit card and must be in U.S. funds. Payment must be received in advance.

Resource Base. Sessions titled Biomass, Wastes and Residues, and Feedstock Research were presented. Since the First Biomass Conference of the Americas was presented in 1993, only limited efforts have been devoted to the installation of dedicated, stand-alone or integrated biomass production systems. Some analysts believe that such systems will not be competitive with fossil fuels until the year 2020. Barring legislation that limits fossil fuel consumption because of carbon taxes or wars and global conflicts that disrupt the production and distribution of oil, the low market prices of petroleum and fossil fuels will continue to be the major stumbling block that moderates biomass energy development. The primary use of commercial woody biomass continues to be for pulp and paper manufacture, but energy is a coproduct in most of these plants. Woody biomass is still responsible for more than 80% of the biomass contribution to primary energy consumption in the US, and over half of this amount is from black liquor generated in pulping operations. No dedicated, herbaceous biomass energy crop systems have yet been installed in North America. About 36 million acres of land in the US Conservation Reserve Program and about 14 million acres of set-aside lands may be suitable for up to 5 quad of biomass production without displacing existing food and fiber crop production. This does not include other large areas suitable for biomass forestry and herbaceous crop production that have the potential of increasing energy production several fold without interfering with food and fiber crop production.

Numerous small-scale experimental, economic, and system design studies have been carried out to assess short-rotation woody crop (SRWC) and herbaceous crop production for energy. One of the largest demonstration programs in progress in the US was started in mid-to-late 1993 in Minnesota where hybrid poplar is grown under short-rotation conditions on a few sites that total 5,000 acres. As the results of this program are publicized, a much more rigorous analysis of the potential of short-rotation hybrid poplar for energy will be possible.

Just A Reminder—The SERBEP address has changed recently as follows: Tennessee Valley Authority, Southeastern Regional Biomass Energy Program, CEB 3A, P.O. Box 1010, Muscle Shoals, AL 35662-1010. *For non-U.S. Postal Service mail (UPS, FedEx, freight, etc.)* the delivery address is: Tennessee Valley Authority, Southeastern Regional Biomass Energy Program, CEB 3A, Reservation Road, Muscle Shoals, AL 35661. Please change your records accordingly.

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SEES Meeting—The Southeastern Energy Society (SEES) October meeting, "Integrated Design Engineering With Advanced Simulation," will be held October 18 at the Windham Midtown Hotel, Atlanta, GA. For more information, contact SEES, % GSPE, Suite 226, 1900 Emery St., NW, Atlanta, GA 30318, tel (404) 355-0177, fax (404) 355-0178.

Forestry harvesting techniques are also undergoing significant change. Clear-cutting is being phased out and partial harvesting or thinning operations are being phased in. Some foresters believe that the newer cut-to-length harvesting methods which process whole trees in the forest will result in higher costs for the smaller trees as fuel. One analysis indicates stump-to-mill fuel chip costs in a cut-to-length system range from $48.20 to $66.20/bone dry ton in contrast to whole-tree systems which range from $30.10 to $33.50/bone dry ton for fuel chips. New thinning technologies are being proposed for testing in the forests of the US Northwest after successful California tests. The California results showed that the thinning of overgrown stands reduces tree mortality, provides healthier stands, and may offer biomass fuels at a cost that can make it possible to operate wood-fueled power plants on a stand-alone basis at a profit in competition with "market clearing prices" for electric power.

One of the largest existing uses of wood ash is application to land for liming and nutrients. Studies are in progress to examine the impact of US EPA regulations on this application, particularly heavy metal build-up in the soil similar to that encountered with some municipal biosolids. Untreated wood ashes are not expected to cause a problem, but some chemically treated woods are. Interestingly, several states are reported to issue permits for land application of wood ashes without regard to heavy metal build-up and ash composition.

In the research community, switchgrass seems to be the model energy crop in the herbaceous category and continues to receive considerable attention. Average yields of the best varieties in the third year of growth ranged from 6.8 to 7.5 dry ton/ac/yr in 19 different locations, but were as high as 16.3 dry ton/ac/yr in 1994 in other locations. Several agricultural specialists believe that the higher yields will be obtained from improved management and cultural practices. Large-scale demonstration programs in different geographic regions would appear to be justified based on the information and data accumulated to date so that planting, growth, and harvesting methods can be perfected and the economics finalized. Switchgrass appears to be an ideal candidate for integration with a conversion plant.

Current legislation and environmental policies are not too favorable for MSW-to-energy systems in the US and few new projects are in the pipeline. But 17% of US trash is burned today compared to 2% in 1980. In 1993, 171 facilities were either in the advanced planning stage, temporarily shut down, or operational, compared to the peak year of 202 in 1988. Mass burning technologies are still favored over modular incineration and RDF combustion. About 2,000 MW of capacity are in place.

Power Production. Sessions titled Combustion, Thermal Gasification, Biological Gasification, and Biological Gasification Research were presented. The old art of biomass combustion for steam, heat, and electric power has by no means remained static over the last 10 years. Advanced biomass combustion methods including pulsed combustors, direct-fired combustion turbines, and a variety of pressurized and atmospheric fluidized bed combustion systems have been developed and are either in the demonstration mode or already commercial. Many of the advanced designs offer higher thermal operating efficiencies, lower emissions, and improved economics. An example of an innovative system is the direct-fired combustion turbine operating on pulverized wood. A 391-kW unit is in the demonstration phase and is expected to operate at up to 70% thermal efficiencies in the cogen mode. Combustion takes place in an external combustor with pressurized air from the compressor section of the gas turbine and the combustion gases are conveyed directly through a cyclonic separator to the turbine which drives the generator. Demonstration of the advantages of the cofiring of fossil fuels and biofuels is also making significant advances. One example is the cofiring of coal and wood wastes. The results of pilot-scale

PRM Energy Systems, Inc., of Hot Springs, Arkansas has begun the on-site erection of a 330-ton-per-day rice hull gasification system. Utilizing PRME's patented technology, the biomass gasifier will produce 115 million Btus per hour as an energy source for boiler steam production. The system, a PRME Model KC218, is believed to be the world's largest rice hull gasifier. Startup and operational testing is expected to be completed in late September of this year. Separately, PRM Energy Systems, Inc., announces the formal signing of a licensing agreement with PRiMEnergy, Inc., of Tulsa, Oklahoma. PRiMEnergy will market, manufacture and install biomass gasification systems domestically that practice PRME's patented technology. For more information, contact PRM Energy Systems, Inc., Mr. Ron Bailey, Jr., (501) 767-2100 or PRiMEnergy, Inc., Mr. W. N. (Bill) Scott, (918) 835-1011.

New Publication Available—*Wood Resources Available from North Carolina Landfills 1994*, by Earl L. Deal and Larry G. Jahn is now available. This 85-page directory quantifies the amount of woody material entering waste handling facilities that may be available for use by wood product manufacturers and others. This information serves two purposes. First, the directory is designed to give potential buyers of woody material guidance in locating the type and quantity of material that can be used cost effectively in their manufacturing facilities. Second, the directory is designed to contribute to the reduction of material entering North Carolina waste handling facilities. Included in the directory are the following tables: alphabetical listing of landfills by name; alphabetical listing of landfills by name and woody material flow rates; list of landfills by governmental regions; list of landfills by name and woody material flow rates, for governmental regions; summary of total woody material flow per year for North Carolina; and summary of yearly flow of woody material for governmental regions and state totals. To receive your copy, write to Larry G. Jahn, Dept. of Wood and Paper Science, Box 8003, NC State University, Raleigh, NC, 27695-8003, tel (919) 515-5579, fax (919) 515-7231.

tests indicate significant reductions in pollutants such as NO_x can be obtained without any significant increase in total hydrocarbon or CO emissions.

Demonstration and commercialization of thermal biomass gasification processes for electric power production and other uses continue to progress. Some of the advanced processes that have recently been placed on-line, or that are in the demonstration mode, under construction, or in the design phase include IGT's pressurized, fluidized bed RENUGAS® process in Hawaii, Battelle's indirectly heated, fluidized bed process in Vermont, MTCI's indirectly heated, fluidized bed, Pulse-Enhanced™ steam reforming process in North Carolina and India, MechChem's atmospheric pressure, fixed-bed, down-draft gasifier in North Carolina, the BIOCYCLE plant based on IGT's technology in Denmark, Lurgi's atmospheric pressure, fluidized bed gasifier in Italy for the ENERGY FARM project, and TPS Termiska Processor AB's fluidized bed gasifier in the United Kingdom. These systems produce medium- or low-Btu gases for power production via a variety of configurations, some of which are advanced combined cycle-cogeneration power plants that operate at high efficiencies. Efforts also continue to perfect hot gas conditioning methods that permit prolonged usage of the product gases with turbines without blade damage, and to catalytically treat the product gases to adjust compositions by removing methane and tars before conversion to methanol and other chemicals.

The impetus to install additional systems and capacity for the biological gasification of biomass by anaerobic digestion has been supported in the last few years by the need for improved waste disposal technologies, pollution prevention, and water and air quality. Unlike the energy markets in the '70s and early '80s, the price of natural gas is insufficient today to justify the installation of new anaerobic digestion plants for biogas recovery. The waste biomass feedstocks that are receiving the most attention are municipal wastewaters, municipal solid wastes (MSW), animal manures, and food industry wastes. One of the largest needs in the US is the additional capacity projected to be required for municipal wastewater stabilization. It has been estimated that this will require new capital investments of about $10 billion dollars by the year 2008. The Hyperion Treatment Plant in Los Angeles, which has a contributory population of nearly 4 million people, is a good example of a modern biosolids treatment facility. The feedstock, 490 dry t/d of raw biosolids, produces 220 t/d of biogas (7 million CF/d) and 250 t/d of dried biofuel, which yield a net electrical output of 15.9 MW after satisfying all process and electrical power demands.

Few new anaerobic digestion facilities for non-municipal and MSW feedstocks have been installed in North America in the last few years, but several of the farm-scale, manure-fed systems built in the '80s and several plants supplied with food industry wastes continue to be operated. It has been estimated that 2,000 dairy and 2,000 swine producers could effectively use biological gasification for simultaneous energy production and waste stabilization. Most of the activity, however, has occurred in Central Europe where a total of 470 manure-fed, small- and large-scale farm plants and community plants are operated. About 20 MSW-fed plants are in operation and another 15 or so are currently under construction or in the planning stage. Some of the newer plants and facilities in North America and Europe use advanced anaerobic reactor designs and system configurations that evolved from the research carried out in the '70s and '80s.

A defacto anaerobic digestion technology that is well established and widely used in the US is the recovery of landfill gas (LFG) from municipal landfills. It has been estimated that as many as 750 additional US landfills could be used to cost-effectively recover LFG. In 1994, about 80 LFG recovery systems were operational and 120 were in the planning stage in the US compared to less than a total of 20 in the early '80s; 645 MW of LFG-to-power capacity was in place in 1994 and total LFG production was about 540 MCF/d. In the last 3 years, it was reported that the total number of LFG recovery facilities grew by 35%.

Transportation Fuels. Sessions titled Biodiesel, Alcohols, and Pyrolytic Liquids were presented. Biomass-based triglycerides have been investigated as alternative fuels for compression ignition engines since the late 1800s. Work was initiated again in the '70s and early '80s to refine the technology. Performance is considerably improved by conversion of the triglycerides to alkyl esters of the long-chain fatty acids by transesterification with methanol or ethanol. The mono esters have been termed biodiesel, but triglyceride-derived liquid hydrocarbons produced by hydrotreatment that are suitable as diesel substitutes have also been called biodiesel. The mono esters have been marketed in Europe, although they are not a commercially viable fuel when compared with current diesel prices in most OECD countries unless some form of government incentive is provided or credits can be taken for the environmental benefits of biodiesel. An intensive effort is underway in the US by many different groups to develop national standards for biodiesel as neat fuels and in blends with diesel, to conduct engine, vehicle, emissions, toxicity, and materials compatibility tests, and to find methods of reducing ester costs. These groups are also working with the vehicle manufacturers to ensure that new-car warranties are not adversely affected by use of biodiesel. Almost all of the performance characteristics of biodiesel have been reported to be equal or superior to conventional diesel. A potentially important technical development that may reduce biodiesel costs is the discovery that use of the proper cosolvent permits single-phase transesterification to occur at much higher rates than the conventional two-phase process. The key to lower costs of biodiesel, however, is to find methods of significantly increasing triglyceride oil yields.

Progress continues on the conversion of lignocellulosics to fuel ethanol. Various technical advances have been reported to reduce the production cost of ethanol from $4.60/gal in 1980 to the point where it is now competitive with ethanol from corn. Further advances are expected to reduce the cost toward DOE's goal of $0.67/gal, which is expected to be competitive with gasoline from petroleum crudes at $25/bbl. Process improvements under development that may help achieve this goal are the genetic manipulation of selected organisms to facilitate simultaneous fermentation of the pentoses and hexoses, the capability of recycling a substantial fraction of the active enzyme fraction, and the immobilization of active enzymes and organisms on substrates in ways that simplify the process design and minimize capital costs. Commercialization activities for processes incorporating enzyme-catalyzed hydrolysis of lignocellulosic feedstocks have been started by several companies. An old argument that has still not been fully laid to rest concerns the net energy production of fuel ethanol from corn. An analysis by USDA indicates a net energy production ratio for ethanol of 1.24 when fertilizers are produced by modern plants, corn is converted in modern facilities, farmers grow corn at normal yields, and energy credits are taken for the basic coproducts. An interesting field test comparison of E-95 and gasoline in a custom sports car equipped with a GM 2.5-L, 4-cylinder engine and a 4-speed manual transmission showed that E-95 produces significantly less CO and hydrocarbon emissions. The gasoline equivalent fuel economy and the energy consumed per unit distance increased by 8.1% and 9.1%. But because of the lower energy density of E-95 and its cost per unit volume, the operating cost was 91% higher without federal and state taxes—$2.73/100 km for E-95 vs. $1.43/100 km for gasoline.

Despite its long history in North America, which includes the start-up of several demonstration and commercial plants and then their shut-down or dismantling, the development of biomass pyrolysis processes for the production of liquid fuels is still in the research stage. The basic chemistry is well known and was used for chemical production until the early '30s, but none of the scale-up work done in the '70s and '80s resulted in sustained plant operations for liquid fuels. Today, most of the research effort is aimed at short-residence-time pyrolysis processes. Maximum liquid yields occur at about 500° C with vapor residence times of one second or less. The acidic oils are highly oxygenated and can be

Brochure Available—The Dutch Energy from Waste and Biomass Program (EWAB) is concerned with the implementation of government policy in respect of promoting the application of waste and biomass as sources of energy. A brochure entitled *Energy from Waste and Biomass*, which gives an impression of the overall EWAB program is now available. The projects being currently undertaken within the context of this program are mentioned in outline. These projects are incorporated in the EWAB Project Overview (Report Number 9507). To obtain the brochure and the EWAB Project Overview, contact MHP Management & Secretary Services, P.O. Box 127, 3950 AC, MAARN, The Netherlands, fax +31-(0)3432-1936.

upgraded by catalytic and non-catalytic processing. Only one process of this type, Ensyn Technologies, Inc.'s, Rapid Thermal Processing (RTP™), has been commercialized in North America. It is offered with process guarantees. Several RTP plants for the manufacture of a variety of products, including fuel oils and specialty chemicals and products such as food flavorings, are expected to be on-line in the next few years. Two commercial plants have been built. The largest is a 50-green ton/d plant in Wisconsin that produces specialty food chemicals and boiler fuel. The oil from RTP has been reported to have the potential of being used directly in diesel blends or in combination with oxygenates after suitable processing. Catalytic conversion of wood oils from RTP is also reported to yield mainly aromatic, aliphatic, or mixed hydrocarbons depending on the catalyst used. In research on other pyrolysis systems, conversion at 500° C and vapor residence times of 0.4 seconds is reported to convert hybrid poplar and switchgrass feedstocks to liquid fuels having higher heating values of about 9,500-9,900 Btu/lb and 10,300-10,800 Btu/lb.

Chemicals and Products. Sessions titled Chemicals and Products were presented. Up to the early part of this century, biomass (and coal) were the preferred feedstocks for the manufacture of organic chemicals. Since then, natural gas and petroleum have become the feedstocks of choice because of economic and technical reasons. Chemicals from oil in the US account for 3 quads of energy-equivalent feedstock. But biomass is still the preferred feedstock for the production of cellulosics and derived cellulosic polymers and plastics, many specialty chemicals and pharmaceuticals, and a few commodity chemicals. A few major ethanol-producing countries such as Brazil initiated a fermentation ethanol-based organic chemical industry several years ago. Research aimed at the development of economically competitive organic chemicals from biomass feedstocks is continuing with emphasis on processes that take advantage of the oxygenated nature of biomass. This work has focused largely on fast pyrolysis processes and fermentation, often in combination with genetic engineering methods. Some examples of recent work with biomass feedstocks are aimed at the development of processes for production of indigo dye, polyhydroxyalkanoates, phenolformaldehyde resin substitutes, and anhydrosugars. Our increased understanding of the mechanisms and controlling factors of biomass pyrolysis has led to experimental demonstration that shows it is possible to carry out biomass pyrolysis in an oxidizing atmosphere to destroy a substantial part of the lignin-derived impurities with little effect on anhydrosugar yields. This should simplify the recovery of anhydrosugars from the lignin impurities, the separation of which is a major problem.

A large number of projects are underway to incorporate biomass and biomass components into useful products and formulated products, many of which are commercially available today. These include reinforcing fillers in plastics and cements, graphitic carbons, laminating adhesives, agricultural composites, densified wood waste and urban waste pellets and fuels, briquettes from mixtures of biomass and cleaned coal, and agricultural fibers for pulp and paper manufacture. An interesting development is the 24-ton "Biotruck 2000" that integrates the operations of harvesting, particle size reduction, heating, and compression of agricultural biomass at about 120-180° C into 1.2-kg/L pellets without binder. This land vehicle is reported to be the first to use waste heat of the engine in the pelletizing process, and to afford fuel pellets that have higher heating values relative to the dry biomass. The latter observation suggests that more than physical densification alone is occurring in Biotruck 2000. Partial thermal dehydrogenation probably occurs via mild pyrolysis to yield higher carbon content products.

Economic, Financial, and Policy Issues. Sessions titled Economics, Capital Availability, and Government Policies were presented. With the exception of projects that are driven by environmental issues and waste feedstocks with negative costs, salable energy cost at the plant gate is at the heart of almost any biomass project. Today, the economics of many biomass projects range from poor to not-quite-competitive because the market prices of

Publication Available—*Power Plays, Profiles of America's Independent Renewable Electricity Developers*, which profiles 100 US companies spearheading development of power plants fueled by renewable resources ranging from wind to the earth's heat, identifies a significant decline in planned capacity. *Power Plays* (528 pp.) contains assessments of seven renewable technologies—biomass, geothermal, wind, small hydro, photovoltaics, solar thermal, and ocean. *Power Plays* is the third in a series of renewable energy assessments that includes two earlier editions published in 1989 and 1986 by the Investor Responsibility Research Center (IRRC). IRRC is an independent, not-for-profit firm that provides impartial research and analysis on business and public policy issues. The report is available for $195 softbound ($210 hardbound) from IRRC. A *Power Plays* data base is available for $255. Contact IRRC, 1350 Connecticut Ave., NW, Suite 700, Washington, DC 20036-1701, tel (202) 833-0700, fax (202) 833-3555.

natural gas and petroleum continue to be low. For example, during the '80s, Maine's biomass power industry grew to nearly 500 MW of installed capacity in 21 cogen and stand-alone plants, which consumed nearly 4 million tons of wood fuels annually while providing 25% of the state's electricity. Low oil prices, economic recession, and rising electricity rates now make biomass-fueled power plants some of the most expensive sources of electricity currently available. So in the short term, the future of biomass power in Maine (and several other states) is not promising.

Cutting through all the possible commentary on this problem, this is the quintessential reason why the rate of placing new, dedicated, biomass energy systems on-line at this time is extremely small to non-existent in North America. But biomass energy is not technology-limited. Nevertheless, a considerable effort continues to determine the impact of specific parameters on costs of a wide variety of biomass systems. This work is essential because it can uncover key cost components and opportunities for cost reductions, can delineate cost details and facilitate process comparisons, can provide direction to the development of further technology improvements, can provide estimates of the extent of the improvements needed to achieve certain costs, and can be used to make realistic cost projections. Indeed, this type of analysis has stimulated the initiation of many projects that resulted in significant reductions in biomass energy costs.

The conclusions drawn from recent economic studies are quite interesting. The cost of electricity is much less at all scales for gasifier-gas turbine combined cycles (BIG/GTCC) compared to steam-Rankine cycles. BIG/GTCC achieve minimum costs at much smaller capacities. With natural gas and coal prices below $2.50/MBtu and $1.50/MBtu, respectively, delivered fuel costs from short-rotation woody crops are too high to allow farm-grown biomass to compete in the electric power market. Doubling of the yields of hybrid poplar, willow, and eucalyptus to 10, 15, and 18 dry ton/ac-yr, respectively, from those assumed in this study provided delivered fuel cost estimates that were competitive with these natural gas and coal prices. If new technologies succeed as projected, biomass-derived electricity might become competitive with power generated from natural gas at 4 cents/kWh in the year 2020. In selected US regions, projected costs for ethanol are 8-15% lower than methanol and the plant capacities needed to achieve minimum ethanol costs are 50% those of the minimum-cost methanol plant capacities. In a study specific to the state of Alabama, a survey of 2,000 farmers resulted in 214 responses and the conclusion that 80% of the respondents would plant an average of 155 ac of switchgrass if they could make an annual profit of $93/ac, which is between the estimated profit for beef ($69/ac) and row crops ($110/ac). The cost of switchgrass production was estimated to range up to $231/ac (for production, harvesting, and hauling yourself) and the gross return at 10 ton/ac-yr was assumed to be $350/ac.

Because of the inherent characteristics of most biomass projects—smaller relative size, higher risk because the technology is not fully established or demonstrated, entrepreneurial nature of project, dependence on tax incentives and government support, can be subjected to major adverse impact by environmental and regulatory changes, fluctuating future profitability in relation to projected competitive energy costs that are not impacted by project—project financing is the method preferred by developers for funding a biomass project. Many renewable energy projects fall below investment grade due to some of these characteristics as determined by the rules and regulations the lenders are often required to follow. But capital can be found for many biomass projects provided the project developer and partners, especially those who bring a sufficient equity position to the project, present up front a successful track record, rational financial and economic analyses, risk mitigation and allocation between the partners, feedstock, energy and biofuel sales agreements, environmental permit agreements, reliable contractual relationships with qualified construction and operating groups and personnel, and a supportive political environment. In other words, there is a very large amount of "homework" that must be satisfactorily completed, often with substantial investment by the project develop-

Available on Internet—Comprehensive Oil & Gas Information Source (COGIS), is a joint project recently developed by the Energy Information Administration (EIA), in cooperation with the U.S. Department of Commerce. COGIS contains virtually all of the oil and gas data published for the last decade by EIA in its *Petroleum Supply Monthly*, *Petroleum Marketing Monthly*, *Natural Gas Monthly*, *Weekly Petroleum Status Report*, and other reports and articles. COGIS is available through the Commerce Department's Economic Bulletin Board, which now offers both Internet and dial-up access. COGIS also provides timely analyses of major oil and gas trends, weekly and monthly highlights of oil and gas activity, and useful information about other EIA projects and services. For information, call EIA's National Energy Information Center, (202) 586-8800. To open an account, call the U.S. Department of Commerce, Office of Business Analysis, (202) 482-1986.

NYSERDA Report Available—The Atlas Bio-Energy Corporation is proposing to develop and operate a 3-MW power plant in Brooklyn, New York. The plant will produce electricity by gasifying waste wood and combusting the low-Btu gas produced in a conventional package steam boiler coupled to a steam-electric generator. The objectives of this project were to assist Atlas in addressing the environmental permit requirements for the proposed power plant and to evaluate the environmental and economic impacts of the plant as compared to more conventional small power plants. The specific components of this research included: developing a permitting strategy plan; characterizing New York City waste wood; characterizing fluidized-bed gasifier/boiler emissions; performing an environmental impact analysis; preparing an economic evaluation; and discussing operational and maintenance concerns. A limited number of copies of *Environmental Assessment of the Atlas Bio-Energy Waste Wood Fluidized Bed Gasification Power Plant* (Report 95-12) are available from the New York State Energy Research and Development Authority, 2 Empire State Plaza, Suite 1901, Albany, New York 12223-1253, (518) 465-6251, ext. 241.

ers, to attract funding. An example of a project where all of the above were carefully planned and structured is the 60-MW,wood-waste-fueled, Williams Lake Project in British Columbia. When financial closing occurred in 1991, this project was the largest independent power plant debt financing in Canada and the second largest non-recourse financing in Canada. It was also the first Canadian non-recourse transaction funded by a syndicate of Canadian life insurance companies and pension funds, who provided $135 million (Can.) of 22-year, fixed-rate debt, prior to completion of construction. The initial RFP was issued by British Columbia Hydro and Power Authority in December 1988; commercial operation of the plant began on April 2, 1993.

In addition to commercial banks and private institutional investors such as insurance companies, multi-lateral agencies such as the World Bank (Bank), which lends only to governments, and its group subsidiaries such as the International Finance Corporation (IFC), the private-sector arm of the Bank, fund biomass projects. Between 1980 and 1993, the Bank financed a total of 40 projects directly related to fuelwood supply and conservation at a total cost of about $1 billion. In 1992, the Global Environment Facility (GEF) was created by the Bank to provide grants for projects in energy efficiency, renewable energy, and other areas. GEF is expected to provide grant financing of $23 million to demonstrate a 30-MW power plant in Brazil based on the BIG/GTCC concept fueled with eucalyptus and sugar cane bagasse.

The energy and tax policies of national governments can of course have a great impact on the development of biomass energy. Canada and the US are perhaps two of the most progressive countries to enact favorable legislation to help establish the biomass energy industry. There are at least eight US tax subsidies for biomass projects buried in the Internal Revenue Tax Code so it behooves the entrepreneur to structure each biomass project to take advantage of these benefits. Since the late '70s, the contribution of biomass energy to US primary energy demand has almost doubled, in part because of these subsidies. Canada's experience is similar. One of the indirect tax subsidies on the horizon that would benefit biomass development is a carbon tax on fossil fuel consumption. Although one might expect widespread resistance to such legislation, Finland is reported to have enacted such a tax. Canada, the US, and many industrialized countries have provided large loans and grants to help promote the development and commercialization of biomass technologies and to support biomass research. With only a few exceptions, such as Brazil, which has a long history of promoting fuel ethanol, the national governments of most South American countries have generally focused their energy policies on fossil fuels. Only limited attention has been given to renewables, but this is expected to change, particularly as environmental problems increase. The European Commission is currently funding a study on "Strategies for the Development of Biomass in Industrialized Countries." This study surveys 12 countries and will help guide the future of biomass energy in Europe. Many countries in Europe already have substantial national and regional programs in operation to stimulate biomass energy usage. Present usage in Europe emphasizes heating, but the survey at this point indicates that biomass could become a prime resource for electric power and vehicular fuels.

Possibly the best example of a regional biomass program that encountered serious difficulty because of the interaction of government policies and market forces is the biomass power industry in the state of California. During the '80s, the industry grew at an average rate of 28%/yr, and by 1990 had 807 MW of biomass power capacity in place and a demand of about 7 million dry ton/yr of biomass fuel. Since then, capacity has been reduced by more than 250 MW due to buy-outs and shut-downs, over half of which occurred in the first 4 months of 1995. Biomass power has become too expensive to compete, as occurred in the state of Maine. The California Public Utility Commission announcement to restructure the electric power industry in early 1994 to make power available to the consumers at the lowest price via retail wheeling, which makes electric utilities power distributors, had a severe ad-

verse impact on biomass power. The goal is similar to the federal objective when the natural gas industry was restructured and is supposed to increase competition and deliver energy at lower prices. The California plan has since been replaced by wholesale wheeling, which permits the utilities to buy power at the lowest prices available to them. All of this has resulted in a slump in biomass power production and several initiatives by the California Biomass Energy Alliance to help save the industry, but the ultimate outcome is unknown at this time.

Sustainability and Environmental Issues. Sessions titled Climate Change, Biomass Utilization, Integrated Biomass Energy Systems Studies, and Technology Barriers were presented. The largest portion of the build-up of the greenhouse gas, CO_2, in the atmosphere, and its possible impact on climate change, have been attributed to fossil fuel consumption. Climate change phenomena, whether perceived or real, are also inextricably related to biomass which is both a source and sink of CO_2. The role of biomass is inestimable in sustaining the global carbon cycle and maintaining the delicate balance in the atmosphere, hydrosphere, and biosphere. The impacts of biomass growth, removal, and replacement are now receiving serious attention by several public and independent utilities, some of whom are directly involved in carbon offset programs. In these programs, woody biomass is grown as a carbon sink to offset the CO_2 emitted by the utility's fossil-fueled plants. This effort is in a pioneering stage and is expected to lead to optimized methods for selection of growth areas, tree species, and planting methods so that the resulting forest is an effective carbon sink. In the program underway at PacifiCorp, the costs of carbon offsets are in the range $1.50 to $2.00/ton at a zero discount rate. Based on my examination of many papers and reports on climate change and atmospheric greenhouse gases, I firmly believe that new biomass growth via reforestation is the only practical solution to global greenhouse gas build-up.

In contrast, biomass burning is reported to release more than 300 compounds into the atmosphere. Among them, in addition to CO_2, are the greenhouse gases CO, CH_4, N_2O and O_3. The short-term time scales such as those involved with the annual burning of savanna and commercial grasslands result in little net effect because the biomass is replaced in the next growing season. The moderate-term cycles involved with wood burning for heating and cooking are also believed to have little net effect, but could lead to some increase in atmospheric CH_4 and N_2O. However, the long-term cycles and sometimes permanent destruction of biomass involved with slash-and-burn agriculture, clear-cutting of forests, and the expanding population are believed to be capable of causing serious environmental impacts. The trends of biomass burning are not known, so all of us in the biomass energy community should be cognizant of the potential problems. It would seem appropriate that our motto should be "Use all that you take, and at a minimum, replace all that you use!"

This motto naturally leads to questions regarding the sustainability of biomass energy utilization. The dictionary defines "sustainability" in several different ways, the simplest being "capable of being sustained and maintained." Many groups are performing biomass energy systems analyses that inherently incorporate sustainability into the design, and by definition, biomass is a renewable resource. So the assumption of sustainability is almost automatic. But there are many technical and operating factors, all of which must be examined in detail to ensure sustainability. Every project is different. As defined by Vice President Gore, "Economic progress without environmental destruction. That's what sustainable development is all about." Sustainable biomass utilization fits this definition.

The US DOE is funding several feasibility studies in the program titled "Economic Development Through Biomass Systems Integration" with the ultimate goal of demonstrating the integrated operation of dedicated biomass production and conversion. This program is the first step in selecting technologies for scale-up and is expected to result in the construction and sustained operation of reasonably large-scale systems in carefully selected locations in different geographic regions. Among the feasibility studies reported on were a willow dedicated feedstock supply system (DFSS) for cofiring with coal for power production in New

Sustainable Agriculture Systems—Sustainable agriculture embodies many concepts in its attempt to integrate all the aspects of farming systems into a holistic system. This book explores the processes that occur within the components of a sustainable system and shows where we can build upon our existing knowledge to develop the concepts of sustainable agriculture into the new conventional agriculture. Researchers examine a variety of aspects, including production goals, environmental considerations, and economics, to build a knowledge base that allows readers to see where changes in agriculture must be made and how challenges can be met. They compare existing systems against definitions of sustainability and pinpoint those areas where improvements can be made in current systems to further the concepts of sustainability. Featured are discussions of concepts of sustainable agriculture and management practices, pest management, and economic aspects of change. Copies may be obtained from Lewis Publishers, 2000 Corporate Blvd., NW, Boca Raton, FL 33431, tel (407) 994-0555. Cost is US $89.95. Outside U.S. $108.00. Cat. No. is L1049PBL.

York, switchgrass and big bluestem/indiangrass DFSS for fast pyrolysis and power production in Kansas, biomass DFSS, probably loblolly pine, and black liquor from a pulp mill for advanced gasification and power production in North Carolina, alfalfa DFSS for advanced gasification and power and animal feed supplement production in Minnesota, switchgrass DFSS for cofiring with coal for power production in Iowa, grass and cane DFSS for power production in Puerto Rico, and cane and other biomass DFSS for a conventional ethanol plant and presscake and lignocellulosics conversion for an advanced ethanol plant in Florida.

The use of monocultures in large-scale biomass energy plantations could present several technology barriers to the owner/operator that have not yet been analyzed in depth. It was reported that intensive agricultural monocultures are very different ecologically from natural systems. Monocultures need larger energy investments to be maintained and they are more susceptible to pests. The strategies proposed to overcome these potential problems are to adjust the scale of plantings to improve habitat conditions for the target species, deploy crops in ways that are complementary to the habitat qualities of the other landscape elements, and develop mixtures of crop varieties and clones and multispecies polycultures as biomass energy crops. Another potential problem area concerns the environmental effects of large-scale conversion of agricultural lands to biomass energy crop production. These systems should be closely monitored to determine the positive and negative environmental effects and benefits, runoff quality and quantity, erosion, and changes in soil characteristics. Data from large-scale plantings of switchgrass and hybrid poplar will be used to develop the best crop management strategies to enhance the environmental benefits.

European and Latin American Biomass Energy Developments. Although many papers on European and Latin American biomass energy developments were presented in other sessions depending on the subject of the paper, separate sessions were also presented on more generic developments in these areas of the world. As already implied in this article, the European Union has an intensive program underway to develop a large-scale biomass energy industry. Several biomass energy technologies have been commercialized, are in the advanced planning stage, or outnumber the corresponding commercial ventures in North America. In the latter category are thermal gasification plants, anaerobic digestion of municipal solid wastes, pyrolysis systems, and biodiesel production.

The Latin American program on biomass energy, again with the exception of Brazil's efforts, is small relative to the North American program and tends to focus on small biomass-fueled electric power production plants in rural locations and biomass utilization for heating and cooking in rural households. Some studies indicate that for countries such as Guyana, which must import large amounts of oil, there is an urgent need to increase the use of indigenous fuels. As a first step toward solving this problem, the "Energy Policy of Guyana" was formulated in 1994. It is expected that trees planted in energy plantations near coastal communities will help increase biomass energy usage and reduce the consumption of petroleum products imported for generating energy. The Brazilian fuel ethanol program—Proalcool—established in 1975, is reported to face a decisive moment in its history because of alcohol supply problems and the possibility of another shortage. Although a technical success, the energy scenario is quite different now because oil prices are lower than projected, and domestic petroleum production has grown considerably. Government incentives for fuel ethanol consumers are essential for survival of the program.

Panel Discussion. One of the highlights of the conference was the last event—presentation of the panel discussion "How Can the Entrepreneur Commercialize Biomass Technology Through Powerful Partnerships." The three panel members and chair were composed of experts with hands-on experience and track records in project financing and the assembly of project teams and partnerships for the commercialization of virgin and waste biomass-fueled power plants, LFG recovery and utilization, and methanol and pyrolytic liquids from biomass. One panelist was also involved in the development of financing a plant to manufacture fuel ethanol from rice straw. It was evident that there is no shortage of technologies, but it was

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Council for Agricultural Science and Technology (CAST) Interpretive Summary, July 1995—The Conservation Reserve Program (CRP) was created in 1985 to encourage farmers to retire highly erodible cropland in return for annual rental payments and a one-time conservation practice cost share payment. This CAST report summarizes CRP policy literature and a survey of key special interest groups regarding their preferences for a future CRP. The purpose of this report is to make CRP evaluation easier by placing literature and preference information in a single document. *The Conservation Reserve: A Survey of Research and Interest Groups* was written by three authors and reviewed by three additional scientists. The full 44-page report, Special Publication No. 19, is available for $12 plus $3 postage and handling from CAST. Individual and student members of CAST may request a free copy; please include $3 postage and handling. Contact CAST, 4420 West Lincoln Way, Ames, IA 50014-3447, tel (515) 292-2125, fax (515) 292-4512.

Calendar of Events

October 12-13, 1995
Denver, Colorado
Integrating Renewable Energy Technologies with Gas Turbine Systems
Mark Mehos, NREL, 1617 Cole Boulevard, Golden, CO 80401
tel (303) 384-7458
fax (303) 384-7495

October 23-26, 1995
Baltimore, Maryland
Wastecon 1995, SWANA's 33rd Annual International Solid Waste Exposition
SWANA, P.O. Box 7219, Silver Spring, MD 20907-7219
tel (301) 585-2898
fax (301) 589-7068

November 1-3, 1995
Kissimmee, Florida
BioCycle Southeast Conference, Composting & Recycling Organic Residuals
tel (800) 661-4905
tel (610) 967-4135

November 7-9, 1995
Chicago, Illinois
1995 Consortium for Plant Biotechnology Research Symposium
Dorin Schumacher
1220 Potter Drive, Ste 130-D, West Lafayette, IN 47906-1383
tel (317) 463-4000
fax (317) 497-3168

November 13-15, 1995
Allentown, Pennsylvania
Fluid Bed XI
Registrar, Council of Industrial Boiler Owners, 6035 Burke Centre Parkway, Suite 360, Burke, VA 22015
tel (703) 250-9042
fax (703) 239-9042

November 14-15, 1995
Arlington, Virginia
8th International Incinerator Ash Management Conference
Coordinate Group, Box 3356, Warrenton, VA 22186-1956
tel (540) 347-4500
(800) 627-8913
fax (540) 349-4540

November 14-16, 1995
Washington, D.C.
First Joint Annual Meeting of the National BioEnergy Industries Association and the Utility Biomass Energy Commercialization Association
Angela Barbara, UBECA, (202) 296-8663, fax (202) 223-5537 or Brandy Smith, NBIA, (202) 383-2540, fax (202) 383-2670.

December 4-5, 1995
Arlington, Virginia
Sustainable Development and Global Climate Change
Center for Environmental Information, 50 West Main Street, Rochester, NY 14614-1218
tel (716) 262-2870
fax (716) 262-4156

December 6-8, 1995
San Diego, California
SAE International Alternative Fuels Conference & Exposition
Sandi Kline, Alternative Fuels Conf., SAE, 400 Commonwealth Dr., Warrendale, PA 15096-0001

1996

March 22-25, 1996
Charlotte, North Carolina
Hearth & Home Expo '96
Hearth Products Association, 1555 Wilson Blvd., Suite 300, Arlington, VA 22209
tel (703) 875-8711
fax (703) 812-8875

April 13-18, 1996
Asheville, North Carolina
Solar 96, National Solar Energy Conference
American Solar Energy Society, 2400 Central Avenue, Suite G-1, Boulder, CO 80301
tel (303) 443-3130
fax (303) 443-3212

April 14-17, 1996
Sun City, South Africa
11th International Symposium on Alcohol Fuels
Professor R. K. Dutkiewicz, Energy Research Institute, University of Cape Town, P.O. Box 207, Cape Town, 7800, South Africa
fax (27) (021) 705-6266

May 5-9, 1996
Gatlinburg, Tennessee
Eighteenth Symposium on Biotechnology for Fuels and Chemicals
Brian H. Davison, Oak Ridge National Laboratory, PO Box 2008, Bldg. 4505, Oak Ridge, TN 37831-6226
tel (423) 576-8522
fax (423) 574-6442

May 20-24, 1996
Banff, Canada
Developments in Thermochemical Biomass Conversion
Dr. Tony Bridgwater, Energy Research Group, Aston University, Birmingham B47ET, United Kingdom
tel: +44 121 359 3611 ext. 4647
fax: +44 121 359 4094

June 24-27, 1996
Copennagen, Denmark
9th European Bioenergy Conference
DIS Congress Service Copenhagen A/S, Herlev Ringvej 2C, DK-2730, Herlev, Denmark
fax +45 - 4492 5050

July 14-18, 1996
San Diego, California
Fifth World Congress of Chemical Engineering
AIChExpress Service Center
345 East 47th St.
New York, NY 10017-2395
tel (212) 705-7373
fax (212) 705-8400

September 15-17, 1996
Nashville, Tennessee
ASAE Liquid Fuel and Industrial Products From Renewable Products
Susan Buntjer, ASAE, 2950 Niles Rd., St. Joseph, MI 49085-9659
tel (616) 428-6327
fax (616) 429-3852
e-mail buntjer@asae.org

September 15-19, 1996
Nashville, Tennessee
Bioenergy '96--The Seventh National Bioenergy Conference
Phillip Badger, TVA Southeastern Regional Biomass Energy Program, Muscle Shoals, AL 35662-1010
tel (205) 386-2925
fax (205) 386-2963

SERBEP Update
Southeastern Regional Biomass Energy Program
Tennessee Valley Authority, CEB 3A
Reservation Road
P.O. Box 1010
Muscle Shoals, AL 35662-1010
(Non-US Postal Service Zip Code 35661)

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clear from the panel discussion that it is difficult to commercialize most biomass ventures at this time.

In North America, environmental issues, especially those concerning waste disposal and air and water quality, have been an invaluable *causa sine qua non.* But capital for new projects is not as readily available as in past years, tight government budgets are causing reduced cofunding opportunities with industry, several tax incentives for renewable energy are under critical review or will end unless extended by legislation, and some governments are restructuring the rules and policies for marketing energy resources, particularly in the power sector, to increase competition and to provide the consumer with energy at the lowest cost. And above all, the price of oil is still low.

So the question posed by the title of the panel is a difficult one to answer at this time. Perhaps the best advice that emanated from the panel discussion to help the biomass entrepreneur succeed under current conditions is to concentrate on well established niche markets by deploying economically favorable technologies that have been demonstrated on a "large rate" (a relative term) and to be very careful to take advantage of *every* tax incentive and environmental benefit available. This means that the developers and purveyors of the more innovative technologies will have a much greater hurdle to overcome because demonstration of the technology in question on a large scale in a first-of-a-kind plant entails more risk and is therefore more difficult to attract capital. This may strike some as a "chicken-or-egg" situation, so markets outside North America may be more amenable to biomass project development until the price of crude oil stabilizes at what I consider to be normal levels, at least $25/bbl or more.